California Regional PM_{10} and $PM_{2.5}$ Air Quality Study (CRPAQS)

Statement of Work – CRPAQS Data Analysis Task 1.1a
EVALUATION OF SAMPLING METHODS, LIGHT-SCATTERING MEASUREMENTS

STI-902321-2288-WP
Sonoma Technology, Inc.

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Introduction

During the measurement phase of the CRPAQS study, b_{sp} (the component of the light-extinction coefficient due to light scattering by particles) was included because b_{sp} measurements are relatively inexpensive and can be made with high time resolution, and it has long been known that b_{sp} is highly correlated with $PM_{2.5}$ concentrations (see, for example, Waggoner et al., 1981). The b_{sp} measurements will make it possible to estimate $PM_{2.5}$ concentrations with 5-minute time resolution at all of the approximately 70 sites where b_{sp} measurements were made. No other CRPAQS measurement provides estimates of PM concentrations with comparable time resolution and spatial distribution throughout the CRPAQS study area.

The relationship between b_{sp} and $PM_{2.5}$ depends on the size distribution and chemical composition of the $PM_{2.5}$ particles. Thus, this relationship typically depends on the geographic location of the measurements and the time of year (Lowenthal et al., 1995; Chow et al., 2001). In some cases, variations in the sources of the $PM_{2.5}$ can cause short-term variations in this relation. Exploration of this relationship during IMS-95 disclosed an excellent correlation between b_{sp} measured by a nephelometer in Bakersfield operated according to the standard ARB Method V protocol (VanCuren, 1989a; 1989b) and $PM_{2.5}$ during the complete wintertime study period (Richards et al., 1998; 1999).

The questions addressed in this task are, what are the accuracy, precision, and validity of the light-scattering measurements and what are the comparability, equivalence, and biases when compared with collocated PM sampling methods?

The Scope of Work below outlines the steps that will be used to assemble and validate the b_{sp} data, determine the relationships between b_{sp} and the PM concentrations, and then use these relationships to estimate $PM_{2.5}$ concentrations. T&B Systems, Inc. is a subcontractor and will perform the task elements indicated in the Scope of Work. A more complete discussion of the approach to be used appears in the proposal. All of the assumptions in the proposal appear still to be valid and are incorporated in this Statement of Work by reference.

Scope of Work

1. Assemble and complete the validation of the RR 903 nephelometer data. It is expected that STI and T&B Systems will work cooperatively on the following task elements. Each

organization will perform these task elements on data that each collected during the measurement phase of CRPAQS, and the results will be shared. Dr. Willard Richards will provide technical guidance to both STI and T&B.

1.1. Download available data recorded by the RR903 from the CRPAQS database and review for completeness. These data include light scattering by particles (b_{sp}), temperature (T), atmospheric pressure (P), and relative humidity (RH). If missing data are identified, work with Greg O'Brien, ARB, to complete the database. T&B Systems and STI currently have the RR903 data, so work can proceed in the event that extracting data from the main CRPAQS database is delayed.

1.2. Apply calibration factors to selected Level 1 data. Each organization will apply calibration factors to its own data as appropriate, and the results will be shared. (Calibration factors were not routinely applied to the RR903 data during Level 1 validation. The data from some instruments will be improved by applying calibration factors.)

1.3. When corrections to the RR903 data are identified through application of calibration factors or comparisons with collocated measurements described below, document these corrections and follow the established procedures to submit them to the CRPAQS database.

2. Determine the relationship between the RR903 b_{sp} and collocated measures of $PM_{2.5}$ and PM_{10}.

2.1. Obtain all available CRPAQS data from measurements collocated with RR903 nephelometers for the following parameters: all measures of PM (MiniVol, Beta attenuation monitor [BAM]; DRI Sequential Filter Sampler [SFS]; Tapered-Element Oscillating Monitor [TEOM]; Federal Reference Method samplers; etc.) and surface meteorology (T, RH, wind speed, wind direction). At many satellite sites, only MiniVol 24-hr PM data will be available. Data from the nephelometers operated according to ARB Method V in the study area will be obtained for the study period along with data from other measurements in the above list collocated with the Method V nephelometers.

2.2. Obtain from DRI the latest results from their ongoing evaluation of the accuracy, precision, validity, comparability, equivalence, and biases of the various PM measurements. It is recognized that different PM sampling methods have different particle-size cutpoints and respond differently to semi-volatile species, such as organics, nitrates, and water.

2.3. Perform regression analyses on stratified data. Factors likely to affect the relationship between b_{sp} and measures of PM include PM composition (fraction of the PM_{10} that is $PM_{2.5}$ and the chemical composition of the $PM_{2.5}$), RH, season, monitoring site, etc. Whether or not the smart heater is heating the RR903 sample airflow may affect the correlations. These analyses will be supported by scatter plots, time series plots, etc. The approach will be similar to that used by Richards et al. (1999) during IMS-95 and will include the determination of the confidence limits on the relationships. Care will be taken during these analyses to account for differences in the operating configuration of the nephelometers, e.g. whether the RH sensor was on the sample

airflow inlet or outlet. Consideration will be given to generating one database in which b_{sp} data from one mode of operation have been converted into estimates of the b_{sp} reading that would have been obtained had the other mode of operation been used.

2.4. These findings will be condensed into simple relationships with confidence limits that can be used to estimate $PM_{2.5}$ concentrations from b_{sp} readings. It is possible that data for the site and season may be useful surrogates for data on the PM size distribution and composition and may help make the simple relationships more practical. In addition, a data file of 5-minute and hour average $PM_{2.5}$ concentrations and confidence limits estimated from the CRPAQS b_{sp} readings will be prepared and submitted to the ARB.

2.5. A brief, non-technical guide to the use of the relationships between $PM_{2.5}$ and b_{sp} will be prepared. One purpose of this discussion will be to help a person with limited training in aerosol science understand the strengths and limitations of these relationships.

3. Meetings and reports

3.1. Dr. Richards and Ms. Siana Alcorn will participate in conference calls, as appropriate.

3.2. Bullet items for the contribution to STI monthly progress reports will be prepared.

3.3. The final product will consist of a journal article to be submitted for peer-reviewed publication accompanied by appendices that will not be submitted for publication.

3.4. A paper will be submitted to the same technical conference as the other CRPAQS Initial Data Analysis papers.

Schedule of Deliverables

Table 1 lists the deliverables to be prepared under Task 1.1a and their planned due dates.

Table 1. Schedule of deliverables.

Deliverable	Deliverable Due Date
Final work plan	January 3, 2003
Data deliverables	
• Level 2 validated b_{sp} data	March 1, 2003
• $PM_{2.5}$ concentrations estimated from b_{sp}	April 1, 2003
Technical Findings	
• Light-scattering efficiencies for $PM_{2.5}$ (and PM_{10})	April 1, 2003
• Light-scattering efficiencies for selected chemical components	April 1, 2003
Draft technical memorandum summarizing findings	April 1, 2003
Final technical memorandum summarizing findings	May 1, 2003
Manuscript for publication	June 1, 2003
Meeting presentation	Fall 2003

Description of Deliverables

The deliverables from this task are

- Level 2 Radiance Research b_{sp} data submitted to the CRPAQS database. STI and T&B Systems will each submit the Level 2 data for the nephelometers operated by each organization.
- Light-scattering efficiencies determined by regression analysis to be used to estimate PM concentrations ($PM_{2.5}$ concentrations) from Radiance Research nephelometer b_{sp} data.
- A database of $PM_{2.5}$ concentrations estimated for each Radiance Research 5-minute b_{sp} reading as well as hour averages of these readings. Each estimate will be accompanied by an estimated uncertainty.
- Light-scattering efficiencies determined by regression analyses for selected chemical components of the aerosol at anchor sites.
- A draft and final memorandum describing the light-scattering efficiencies, the estimated $PM_{2.5}$ concentrations, and the uncertainties in these values. A discussion will provide advice on the use of these data.
- A final product consisting of a manuscript to be submitted for peer-reviewed publication and one or more appendices that include data and discussions not to be included in the publication.
- A presentation of this work at a technical conference, such as the 2003 AAAR Annual Meeting in Anaheim.

ARB Staff Assigned to This Task

The ARB Project Manager assigned to this task is

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STI Staff Assigned to This Task

The STI Project Manager is Mr. Lyle R. Chinkin. The STI Task Manager assigned to Task 1-1a is Dr. Willard Richards. Mr. Don Lehrman will manage the subcontract work performed by T&B Systems.

Percentage of Work, Data Products To Be Performed/Delivered by ARB

No work on this task will be performed by ARB.

Software and Models To Be Used by STI

- Microsoft Word
- Microsoft Excel
- Microsoft Access or SQL server
- STI data validation software, Surfdat

Models, Reports, or Other Data To Be Supplied to STI by ARB

The following data will be obtained from the CRPAQS database and from CRPAQS contractors:

All available CRPAQS data from measurements collocated with RR903 nephelometers for the following parameters: all measures of PM (MiniVol, Beta attenuation monitor, DRI Sequential Filter Sampler, Tapered-Element Oscillating Monitor, Federal Reference Method samplers, etc.) and surface meteorology (T, RH, wind speed, wind direction). At many satellite sites, only MiniVol 24-hour PM data will be available. Data from the nephelometers operated according to ARB Method V in the study area will be obtained for the study period along with data from other measurements in the above list collocated with the Method V nephelometers.

The latest DRI results from their ongoing evaluation of the accuracy, precision, validity, comparability, equivalence, and biases of the various PM measurements. It is recognized that different PM sampling methods have different particle-size cutpoints and respond differently to semi-volatile species, such as organics, nitrates, and water.

References

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Lowenthal D.H., Rogers C.F., Saxena P., Watson J.G., and Chow J.C. (1995) Sensitivity of estimated light extinction coefficients to model assumptions and measurement errors. *Atmos. Environ.* **29**, 751-766.

Richards L.W., Hurwitt S.B., Main H.H., and Chinkin L.R. (1998) Characterization of the validity of light-scattering measurements during the 1995 integrated monitoring study. Report prepared for California Air Resources Board, Sacramento, CA by Sonoma Technology, Inc., Petaluma, CA, STI-997216-1796-FR, July.

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VanCuren T. (1989a) Instrumental measurement of visibility reducing particles. Staff report. Report prepared by Research Division, California Air Resources Board, Sacramento, CA, January.

VanCuren T. (1989b) Instrumental measurement of visibility reducing particles. Technical support document. Report prepared by Research Division, California Air Resources Board, Sacramento, CA, January.

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